

# Activities of the National Institutes of Health Relating to Energy Efficiency and Pollution Prevention

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The National Institutes of Health (NIH) is one of the world's premier biomedical research centers. Although NIH owns and operates more than 1,300 acres and 197 buildings across the country, the main campus is in Bethesda, Maryland. This campus consists of over 312 acres and 75 laboratories and other buildings, which consume vast amounts of energy. Aware of the NIH role in setting biomedical research agendas and priorities, its administrators strive to set good examples in energy efficiency and pollution prevention. Three current projects are presented as "best practices" examples of meeting the stated commitment of NIH to leadership in environmental stewardship: *a)* design and current construction of a 250-bed clinical research hospital designed to allow conversion of patient care units to research laboratories and vice-versa; *b)* design and construction of a six-story research laboratory that combines energy-saving innovations with breakthroughs in research technologies; and *c)* a massive, \$200-million modernization of the campus utility infrastructure that involves generation systems for steam and chilled water and distribution systems for chilled water, steam, potable water, electricity, communications and computer networking, compressed air, and natural gas. Based on introduction of energy-efficiency measures, millions of dollars in savings for energy needs are projected; already the local electric utility has granted several million dollars in rebates. The guiding principles of NIH environmental stewardship help to ensure that energy conservation measures maximize benefits versus cost and also balance expediency with efficiency within available funding resources. This is a committee report for the Leadership Conference: Biomedical Research and the Environment held 1–2 November 1999 at the National Institutes of Health, Bethesda, Maryland. **Key words:** biomedical laboratory design, biomedical research, environmental stewardship, hospital design, laboratory energy use, research energy use, research facility construction, research support infrastructure. — *Environ Health Perspect* 108(suppl 6):939–944 (2000).

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The National Institutes of Health (NIH), which began in 1887 as a one-room Laboratory of Hygiene, is today one of the world's premier biomedical research centers. NIH is recognized as the focal point for all Federal government activities in biomedical research. Because of its prominent role in setting agendas for all aspects of health research, NIH helps determine priorities for environmental stewardship in biomedical research settings. Researchers and administrators at other research centers closely watch NIH decisions. The NIH role in setting agendas and trends applies not only to science but also to the application of science in demonstrating responsible management of research activities and the resulting impact upon the environment. For more than 20 years, NIH administrators have been striving to set good examples in energy efficiency and pollution prevention. The effort involves prudent management of the entire NIH infrastructure—designing, building, and maintaining new laboratories and underground utility systems. The NIH Office of Research Services (ORS) has overall responsibility for planning, designing, and building facilities. ORS is also responsible for the operation and maintenance of the physical facilities managed by NIH. NIH has 75

buildings on more than 300 acres on its campus in Bethesda, Maryland, and owns and operates more than 1,300 acres and 197 buildings across the country.

The NIH budget has grown to more than \$15.6 billion in 1999. More than 80% of those funds are spent not for NIH intramural research program activities in Bethesda but for grants supporting research and training in more than 2,000 research institutions throughout the United States and abroad. NIH grantees of the extramural research program are located in every state in the country.

Like any other commercial or academic research entity, NIH must comply with environmental protection measures. Under the Energy Policy Act of 1992 (1) and a 1999 Executive Order (2), NIH has initiated energy conservation and waste management technologies designed to reduce energy usage by 35% by 2010. As the responsible body, ORS must ensure that the NIH research effort is not hampered by energy conservation efforts and at the same time ensure that maximum public benefits result from our environmental stewardship. It is a balancing act between commitments both to excellence in research and to leadership in energy conservation. It also involves being a responsible neighbor.

Factors considered in this process and the guiding principles of NIH environmental stewardship are *a)* assuring that the overall plan is comprehensive as well as strategic, *b)* assuring that conservation measures maximize benefits versus cost, *c)* providing flexibility and adaptability to meet changing NIH demands, and *d)* balancing expediency with efficiency within available resources.

Planning and implementing a massive environmental management plan requires extensive resources. A number of stakeholders are involved: employees with health and work-safety needs; researchers with expanding needs, hopes, and goals; neighbors in the surrounding residential community in Bethesda; ecological interests and researchers; the U.S. Congress; and the taxpayers who fund the research. Plans and strategies evolve because things change over time. The needs and priorities of scientists grow and progress. Buildings and engineering-support infrastructures age. Unexpected developments occur and technology advances offer alternatives promising a healthier, less polluted environment.

Costs are central to all the other factors. Scientific equipment and research laboratories consume vast amounts of energy, which is generated in plants with varying potentials for pollution. Usually, conservation measures use newer technologies that may require premature replacement of equipment or systems still operating adequately. NIH administrators must decide: Is it worth replacing buildings or cooling systems that are operational in order to achieve the conservation benefits promised by newer technology?

Planning and instituting a comprehensive environmental management strategy for a massive biomedical research enterprise involves a broad range of complex scientific judgments and engineering decisions. We believe that NIH is acting responsibly to fulfill its stated commitment to environmental

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stewardship, as demonstrated in three current projects. In this committee report we discuss three specific best practices examples of environmentally oriented improvement projects conducted at NIH. Two of the examples are building construction projects; the third involves a major infrastructure modernization. The first example is the new Mark O. Hatfield Clinical Research Center, a design prototype combining patient-oriented hospital airflow modeling and control with energy efficiency and unique architectural features. The second example is Building 50, the Louis Stokes Laboratories. It will be a prototype of energy-saving innovation in a research facility. The campuswide utilities modernization project is the third best practices illustration. When completed, it will be an example of successfully and cost effectively retrofitting an aging, massive infrastructure to achieve major environmental protection goals while the entire system continues in service.

## Discussion

### Mark O. Hatfield Clinical Research Center

NIH is constructing a new state-of-the-art clinical research facility. Named the Mark O. Hatfield Clinical Research Center in honor of the former senator from Oregon who served from 1962 to 1996, it will be a 250-bed replacement hospital. Scheduled to open late in 2002, it will contain a total of 850,000 gross square feet of clinical research space, including 250,000 square feet of research laboratories that directly relate to the needs of clinical research and require close proximity to patient beds. This facility is an addition to the existing NIH Clinical Center, which is the primary center for the clinical research program of the Federal government.

The Clinical Center at NIH supports nearly 50% of all Federally funded clinical research beds in the nation, as well as over 25% of outpatient visits associated with Federally funded clinical research. Each year, an average of 20,000 children and adults from across the country and around the world are referred to the Clinical Center for experimental treatment and study.

At any given time, nearly 1,000 clinical research protocols are ongoing at the clinical center. Many of these protocols are involved with the development of new medications, primarily through early assessments of the safety and efficacy of experimental drugs and devices (Phase I and Phase II clinical trials). These trials include long-term epidemiological and familial protocols that are highly innovative, costly, and risky, and some that can be undertaken only by the Federal government. The Clinical Center is also increasingly involved in studies that will lead to

improved medical imaging, novel long-lasting and biocompatible materials for tissue implantation, and improved methods for administering and targeting therapeutic agents. In addition, advances in transplantation research will offer opportunities to assess novel approaches to medical problems, including transplants of cells and tissues grown in the laboratory.

A facility housing clinical research at NIH must satisfy special design requirements that are unique to NIH clinical research. First and most important, the facility must be highly flexible and adaptable to meet the demands of changing research protocols. A normal acute-care patient room should be changeable to an isolation room; a single-patient room should be convertible to a double-patient room; and routine patient rooms should be convertible to day hospital stations. The facility must be adaptable to allow conversion of the patient care units to research laboratories and vice-versa.

Second, given the wide range of diseases being studied at the Clinical Center, the facility must have a highly effective infection control system. Controlling the transmission of airborne diseases is of paramount importance, as the patient population is expected to have a high incidence of compromised immune systems. Appropriate isolation rooms must be provided to house patients with airborne transmissible infectious diseases such as tuberculosis, and appropriate patient protective environment rooms must be provided to house patients who are susceptible to airborne infection, such as bone marrow transplant patients.

Third, the facility must provide a healing environment for the patients—the well-being of the patients is as important as the clinical research being conducted. Each individual patient room should have abundant natural light, be appointed with the finishes that are warm, friendly, and noninstitutional, and be a size adequate to allow family members to spend time with the patient.

The key elements in making the facility flexible and adaptable include the modularization of the floor plan, standardization of the room components, and introduction of the interstitial level (between floors) to house the utility infrastructure. The modularization of the floor plan for the building involves a planning module of 33 feet × 33 feet, divisible by two or three, resulting in a patient room module of 16.5 feet × 22 feet and a research laboratory module of 11 feet × 33 feet. Standardization of the patient room components such as headwalls, toilet and shower, closet, and sink allows the flexibility to change the use of a patient room from a single room to a double room or from a patient bedroom to a day hospital station.

The incorporation of an interstitial level allows adaptability in health care and research facilities, which normally require a far more extensive utility infrastructure than an office building. The interstitial level is a fully accessible, walk-through space above an occupied area devoted to the distribution of mechanical, electrical, plumbing, telecommunication, and fire protection services. The interstitial level provides the necessary access to make mechanical system components interchangeable and allows general maintenance, repair, and alterations of the occupied space below with minimal disruption to the occupants.

The quality of air provided for the clinical areas of the Clinical Research Center project is of great concern for minimizing the transmission of airborne diseases. The basis for the concern is that the patient population is expected to have a high incidence of compromised immune systems. These patients are not expected to be confined to specific areas in the building. Additionally, not all patients have gone through a complete workup prior to entering the facility and thus may be carrying diseases prone to airborne transmission. Industry minimum ventilation guidelines for standard hospital construction allow a central recirculating ventilation system providing about 35% fresh outdoor air and filtration efficiency of 90% for most spaces. Because of the wide range of diseases being studied at the Clinical Center and unknown strains of diseases in the future, NIH determined that the new hospital will be provided with a non-recirculating ventilation system that supplies 100% outdoor air with pass-through 90%-efficient filters.

The new facility will be a showcase of energy-efficiency innovations that include the use of turbine generators for reducing high steam pressure that will yield enough electricity to meet one-sixth of the facility's total energy demands. The use of a variable-air-volume ventilation system consumes substantially less energy than conventional constant-air-volume ventilation systems.

The new Clinical Research Center will also be equipped with both airborne infection isolation rooms and patient-protective environment rooms. Within each patient care block of 24 patient rooms, there is the capacity for up to 4 isolation rooms and 4 patient-protective environment rooms. The ventilation rate for these rooms is 12 air changes per hour. Exhaust from the isolation rooms is separated from the general exhaust to avoid transmission of airborne infectious organisms to other areas of the building and exposure of infectious bacteria to maintenance or construction personnel who may be working on the system. The effluent from the isolation rooms is exhausted above roof level at a velocity of approximately 3,000 feet per

minute. Extensive wind tunnel studies were conducted to establish the location and the height of the exhaust stacks.

Each year, approximately 20,000 patients are referred to the Clinical Center. Many of these patients spend extended periods of time at NIH, and it is important that a healing environment be provided for these patients. Each patient room in the new facility is designed with a large window to allow abundant daylight; gathering areas outside of the patient care units are generously arranged to provide a tranquil atmosphere in which patients and visitors can relax. Each patient room is adequately sized for family members to spend time with the patient and to accommodate overnight stays for a close family member. All patient rooms are appointed with warm and friendly finishes, including vinyl flooring with wood-grain appearance and patterned bathroom ceramic tiles. The facility's large central atrium includes double-helix stairs with dichroic glass skylights casting different color lights on the floor and walls and sitting areas for patients and visitors. Great efforts are made to make the new facility patient friendly.

### The Louis Stokes Laboratories

NIH is replacing obsolete laboratory facilities in three existing buildings by designing and constructing a trend-setting consolidated laboratory facility, Building 50, on the main NIH campus. Congress named the building for Louis Stokes, retired congressman from Ohio noted for his support of NIH. The facility, a prototype of innovative design and energy-saving technologies, is scheduled to open late in 2000. It will be a 290,000 gross square-foot, six-story research laboratory facility with a multiuse conference room, laboratories, support spaces, workstations, and office space. It will house 650 scientists and technicians performing structural and cell biology research in allergy and infectious diseases; heart, lung and blood diseases; diabetes, digestive and kidney disease; arthritis, musculoskeletal, and skin diseases; and research on the human genome. Building construction details and photo galleries are available on the Internet (3).

There will be several specialized areas in Building 50, including an animal vivarium (housing rodents and rabbits) with biological level 3 (BL3) laboratory and quarantine isolation suites, a nuclear magnetic resonance (NMR) lab that will house the world's most powerful NMR unit, and a cryogenic electron microscope suite. The six high-power electron microscopes will generate so much heat that a liquid-nitrogen cooling system is included in the design.

As designed, Building 50 has a very high efficiency (net to gross square-foot ratio) of

60% and the 294,000 gross square-foot area provides 180,000 square feet of useable space. The construction was planned for two phases. Phase 1 began in July 1997; this phase took 7 months to clear the site (which was an existing parking lot), relocate significant existing electrical, sewer, chilled water, and steam lines, excavate the basement, and construct 155 concrete caissons for the foundation. Phase 2 started in April 1998 and is scheduled to be completed by March 2001. There will be a 3-month occupancy phase, and the facility will be fully occupied by May 2001.

The "best value" procurement process, an effective new method of procurement contracting, was used to select construction contractors. Rather than simply awarding the project to the lowest bidder, a committee reviewed and scored the submitted qualifications of the competing contractors and in conjunction with their bids, selected the contractor that the panel felt represented the best combination of price and technical qualifications, or best value, to the government. In both phases the selected contractor was not the lowest bidder.

The Building 50 design has several unique features certain to be appreciated by investigators and technicians. Planning and design input from scientists was vital. Scientists and technicians were surveyed, asked to describe their needs and their likes and dislikes about their current research labs. Architects then presented conceptual design schemes to the future occupants in Building 50 "town meetings" and again solicited occupant feedback.

The laboratories are arranged in six neighborhoods containing seven lab modules on each floor; modules are 11 feet wide with benches 16 feet long. Except for a few labs requiring enclosure because of the nature of their research, all labs are open. Each lab module has an equipment room at the inner face, personal workstations for four post-doctoral scholars, and enclosed corner offices at the exterior wall. Each neighborhood also has a break room with full windows on an outside wall. In each lab, 40% of equipment storage cabinets are roller mounted, which allows user flexibility in the layout of the bench work area; all workstations and labs are equipped with telephone jacks and connections for computer networks. For security, entrances to each neighborhood are equipped with proximity key-card readers to limit access to authorized occupants.

The heart of the building's design is an interstitial mechanical concept that provides access to utilities above the laboratories on each occupied floor. There is a lightweight steel walk-on deck containing most of the heating, ventilation and air-conditioning (HVAC); electrical; and plumbing elements.

This concept speeds up construction; mechanical and electrical tradesmen are able to install their systems on this interstitial level while carpenters simultaneously work on the room finishes below. It also will provide an operating advantage after the building is occupied, as most repairs will not require maintenance personnel to enter lab work areas and remove ceiling tiles to access HVAC, electrical, and plumbing systems.

Each interstitial level curves upward at outside walls, providing double-height windows to flood daylight into the nonlaboratory work areas below, reducing energy demands for lighting. Lighting conservation features include task lighting at work stations, programmable lighting systems to turn lights off at night, and motion detectors in enclosed rooms to turn lights off when rooms are unoccupied.

Research laboratory buildings consume vast amounts of energy because they require the use of "once-only air"—air that is imported, tempered, blown through the building, then exhausted, not recirculated as it is in most buildings. Most laboratory buildings use a constant-volume air supply, in which a preset constant volume of air is continuously supplied to and exhausted from the occupied spaces, regardless of varying air-supply or temperature demands. In contrast, Building 50 uses a variable air volume (VAV) system that changes the volume as well as the temperature of the air supply in response to actual needs. There are separate air exhaust systems for general labs, fume hoods, bathrooms, BL3 labs, fermentation lab, cage wash, and vivarium. VAV systems require more complex air-supply controls and sensors but save considerable energy. By not continuously pumping a constant volume of air (nor requiring reheating of this air) to occupied spaces and then exhausting it, the VAV system saves a considerable amount of energy by supplying only enough air to meet actual demand. Energy savings can vary from 30 to 50%.

Laboratories require extensive use of fume hoods, designed to protect technicians who are working with substances emitting hazardous fumes or gases. Local exhaust ventilation is the primary method used to control inhalation exposures to hazardous or toxic substances. The system consists of a hood, ductwork, an exhaust ventilation fan, and, sometimes, air-cleaning devices or filters. Conventional fume hoods and those with bypass (constant volume) or auxiliary airflows can be inefficient, both in providing protection and in energy consumption. The design of Building 50 uses VAV fume hoods. These hoods vary the exhaust volume as the hood's access sash is opened or closed, thus exhausting only as much air as necessary to meet exhaust demands. VAV hoods require a sash



monitoring system and fume hood controller tied into the air supply and exhaust system of the lab room.

VAV hoods are complicated and more difficult to design, install, and implement than older systems but save significant amounts of energy. All existing NIH fume hoods are constant-volume bypass hoods; Building 50 will be the first facility with VAV hoods. VAV energy savings can be as high as 70% compared to constant volume hoods. However, VAV systems also require more maintenance expertise, and to realize energy savings, all users must be trained and must cooperate in keeping hood sashes closed except when hoods are being loaded for use.

In addition, Building 50 uses variable frequency drives (VFDs) on all major electric fans, motors, and pumps. Rather than cycling on and off, these fans and motors can run at low speeds, producing significant energy savings. Drawbacks to VFDs are higher initial cost and potential noise and harmonic problems. The environmental variables and energy consumption of the building will be constantly monitored. An automated building controls system will monitor and graphically display information regarding operation of air-handling units, exhaust fans, fume hoods, VAV units, room temperature, pumps, heat exchangers, and central utility consumption.

Building 50 is being equipped with energy recovery wheels, 14-foot-diameter discs that rotate alternately through the air supply and exhaust streams to recover heat that would otherwise be exhausted. These heat wheels will provide up to a 50% reduction in peak demand for cooling, heating, and dehumidification of the building. The wheels rotate inside eight giant air-handling units in the building's penthouse, each of which can handle 50,000 cubic feet of air per minute.

Each heat wheel is an aluminum silicate, desiccant-coated honeycomb matrix heat transfer device that recovers total heat, both from the air and from latent heat from water vapor. The building's exhaust system and the air-supply stream are located adjacent to each other; the heat wheels alternately slice through first one, then the other, to transfer energy. In summer cooling mode, the outgoing cool air exhaust flow lowers the temperature of the energy recovery wheel, which in turn then spins through and lowers the temperature of the incoming outdoor air. In winter heating mode, outgoing warmer air exhaust flow raises the temperature of the energy wheel, which in turn then spins through and raises the temperature of the cooler incoming outdoor air. The wheels absorb water vapor and do not allow it to transfer through with the air stream. This filters the humidity out of the

summer incoming air in the cooling mode and contains the humidity in the building and prehumidifies the drier incoming winter air in the heating season.

The innovative design of Building 50, combined with effective procurement and construction decisions, resulted in an unexpected bonus—the addition of an extra floor to the building. During construction it was determined that projected savings would produce a surplus of several million dollars in building costs. A feasibility study showed that it was technically possible to replicate and insert an additional laboratory floor into the still-rising building. There was only a 22-day window of opportunity to act. The decisions were made in time to go ahead, before construction progress made the addition physically impossible, and the five-story building became a six-story building, providing an extra 44 lab modules. The floor was added within the original budget and required only a 2-month project extension.

For the first time at NIH facilities, all utilities of Building 50 are metered so its energy usage can be tracked and benchmarked for future energy conservation efforts. The heat wheels and VAV air systems and other energy-saving features, such as occupancy sensors and the variable-speed motors and fans, provide overall savings of more than 40% in total energy costs. This resulted in Building 50 receiving the Energy and Water Conservation Award of the U.S. Department of Health and Human Services for its energy-saving design. In addition, the local energy provider will be issuing a rebate for energy-efficient design, based largely on savings from the heat wheels. The one-time rebate will total about \$2 million.

### **National Institutes of Health Infrastructure Modernization**

The main NIH central utilities plant, Building 11, is nearly 50 years old. It was built in 1952 to serve only 11 buildings, with subsequent additions and expansions to support the extensive growth of the NIH campus that has occurred since the 1960s. In the late 1980s, it was apparent there were potential problems as the addition of new buildings and facilities threatened to overtax the NIH utility support system. These problems were related to age, capacity, reliability, energy efficiency, and maintainability of the utilities systems. Important portions of the systems were deemed beyond their useful life span, capacities of the systems were strained due to campus growth and expanding laboratory utility requirements, and reliability was being compromised by age, growing demands, and complexity of systems. In addition, energy efficiency was undermined by aging technology, and maintainability of

systems was compromised by deterioration of aging equipment.

The aging utility systems and equipment, combined with a growing public awareness of environmental issues, have prompted mounting expressions of concern from residents living in areas adjacent to the NIH campus. The campus is in the midst of upscale residential neighborhoods that are home to thousands of well-educated and civic-minded homeowners. In recent years these NIH neighbors have expressed anxieties about NIH activities and their impact on the local environment. Concerns were expressed, for example, over highly visible emissions from NIH boilers and noise levels originating from NIH cooling towers. Some homeowners and activists lodged inquiries or complaints over environmental issues with state and county agencies. Neighborhood town meetings were held by residents to discuss their perceptions of noise levels and air pollution questions. NIH representatives attended many of these meetings, seeking both to reassure neighbors about environmental issues and to respond to their specific concerns, particularly those regarding noise levels and visible boiler emissions.

A 10-year master utility program (MUP) was started in late 1989, focusing on modernizing and expanding the utility infrastructure—generation systems for steam and chilled water and distribution systems for chilled water, steam, potable water, electricity, communications and computer networking, compressed air, and natural gas. Goals of the program were to restore and improve reliability, expand capacity to meet current and future demand, and to improve efficiency. Key goals included identifying and implementing steps to minimize environmental impact in four key areas: boiler emissions, noise (cooling towers), ozone-depleting chlorofluorocarbons (CFC) refrigerants, and sanitary sewers handling wastes and materials leaving the campus. The modernization program also called for maximum flexibility throughout to anticipate future growth.

The MUP addresses improvements in three utility systems: chilled water generation, steam generation, and distribution systems. Nine separate distribution systems were addressed: chilled water (piping improvements and hydraulic improvements, including addition of a secondary pumping station), steam, potable water, electrical, telecommunication, sanitary sewer, storm sewer, compressed air, and natural gas.

Following completion of the MUP, an aggressive program of design and construction began in the summer of 1991. This unique design and construction program includes the following major projects: a) expansion of utility tunnels and miscellaneous distribution system improvements

(project completed); *b*) installation of new boiler (2,000,000 lb/hr unit installed; project completed); *c*) modernization of existing boilers (boilers 1, 2, 3, and 4 now being upgraded); *d*) installation of high-efficiency chillers (four 5,000-ton chillers installed; project completed); and *e*) expansion of central heating and cooling system with four new 5,000-ton chillers and a secondary pumping station (now in construction).

The utility tunnel project, completed in February 1999, provides NIH with major upgrades to underground distribution systems by expanding tunnel and trench systems. Installed were 1.8 miles of chilled water piping, 2.9 miles of steam-condensate piping, 0.85 mile of domestic water piping, and more than 30 miles of small piping and electrical conduits. The utility distribution system was upgraded from a constant-speed primary system to a variable-speed primary and secondary system. The conversion to a secondary pumping system allows more efficient distribution of chilled water throughout the campus and will result in annual cost savings in excess of \$720,000.

The steam generation system at NIH employs five balanced draft-watertube boilers to produce steam at 165 pounds per square inch saturated. The two newer boilers installed in 1968 and 1997 are capable of burning either natural gas or diesel fuel #2. The three older boilers installed in 1952 are currently being renovated so they will also be capable of burning either natural gas or oil. Four of the boilers have a capacity of generating 150,000 pounds of steam per hour; the fifth boiler has a capacity of 200,000 pounds per hour.

State-of-the-art electronic microprocessor-based combustion control technology was implemented to control steam generation. This system provides control of air and fuel flow to regulate the combustion process. It controls oxygen levels to assure complete combustion and to minimize carbon monoxide emissions by providing sufficient excess air and draft control to minimize fugitive emissions. A boiler emission curtailment program had three initiatives: *a*) converting all boilers from burning residual fuel oil #6 to natural gas, with diesel fuel #2 as backup; *b*) installation of the microprocessor-based combustion control technology; and *c*) installation of flue gas recirculation and low-noxious burners to further reduce the emissions of nitrogen oxides.

In addition, improvements were made in air dispersion of emissions. These improvements were based on results of combined numerical and wind-tunnel air dispersion modeling tests to accurately understand air dispersion over the NIH campus and the surrounding community. As a result, the

boilers' freestanding 90-foot-high stacks were consolidated into one stack and its height was raised to 125 feet.

At NIH, water is chilled in two central buildings for distribution throughout the campus. Nine old chillers using R-11 refrigerant have been replaced. Because R-11 and R-12 refrigerants are CFCs and their use is controlled by law, complete phaseout of these two chemicals is in progress. Operation of existing R-12 chillers is limited to emergency conditions. As part of the modernization program, four 5,000-ton chillers have been installed and four more are under construction and expected to be in operation in late 2000. All newly installed chillers use R-22 refrigerant. All new chillers presently under design or construction will use R-134a refrigerant. All chillers installed since 1990 use microprocessor-based control technology and have state-of-the-art vibration and temperature-monitoring equipment.

These modernization steps greatly increase energy efficiency for chilled water generation, with considerable estimated savings:

- installation of high-efficiency chillers 18–21
  - initial cost: \$1,600,000
  - utility rebate: \$1,600,000 (1 year)
  - annual savings: \$820,000
- installation of chillers 22–25 (under construction)
  - initial cost: \$1,600,000
  - utility rebate: \$1,600,000 (1 year)
  - annual savings: \$200,000

- installation of steam-driven chillers (used during electrical power emergencies)
  - initial cost: \$2,400,000
  - annual savings: \$330,000
- installation of free-cooling system (under construction)
  - initial cost: \$350,000
  - annual savings: \$220,000

Rebates granted by the local utility company as rewards for energy-efficient upgrades to the NIH infrastructure total \$3,200,000.

In summary, the NIH power-plant expansion included installation of the four 5,000-ton chillers and six 800-horsepower secondary chilled water pumps and installation of the free-cooling system used for winter energy savings. Installation of this system will allow heat transfer between the chilled water closed loop throughout the campus and the condenser water loop, thus allowing cooling of facilities without running the chillers.

To reduce the level of noise emanating from the cooling towers and fans and the impact of this noise on neighboring communities and NIH employees, sound levels at the periphery of the NIH campus were continuously measured over a 2-week period and a noise abatement plan was developed. Achievements to date include *a*) installation of sound-absorbing acoustical walls in the two chiller buildings, *b*) selection of cooling towers with low noise generation characteristics, and *c*) implementation of variable-frequency drives on cooling tower fans to vary fan speed, reducing nuisance noise resulting from frequent on-off cycles of operation.

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## Conclusion

The Mark O. Hatfield Clinical Research Center is designed to meet the requirements unique to conducting clinical research in a patient treatment facility at NIH for years to come. There are challenges in appropriately designing a clinical and research environment that is productive as well as comfortable and safe for the patients and researchers. The resulting design advances in this new facility at NIH have potential for far-reaching influences on the design of new research hospital facilities throughout the country.

When it opens late this year, the Louis Stokes Laboratories facility is sure to win praise from its scientist occupants and from environmentalists seeking examples of energy-conserving innovation. Its energy-saving heat wheels, variable-flow air systems, and other energy-saving features such as

occupancy sensors and the variable-speed motors and fans provide overall savings of more than 40% in total energy costs.

The NIH infrastructure modernization is a best practices example of how careful, long-range planning can be coupled with the application of cutting-edge technologies to modernize extensive utility, heating, cooling, and underground distribution systems to meet rapidly expanding research support demands. It demonstrates how such a vast modernization effort can be conducted with minimal disruption to research projects while the complex systems continue to meet day-to-day demands. It further demonstrates graphically how modernization produces money-saving efficiencies and utility bill rebates.

Finally, these three best practices illustrations show the value of a management commitment to environmental stewardship.

A plan similar to the guiding principles of NIH environmental stewardship can be used by any research facility contemplating expansion needs. Such a comprehensive plan can assure that conservation measures maximize benefits versus cost, provide flexibility and adaptability to meet changing demands, and balance expediency with efficiency within available resources.

## REFERENCES AND NOTES

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